# Neglect Benevolence in Human Control of Robotic Swarms

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## Introduction

Robotic swarms are distributed systems whose members interact through local control laws. The local control laws enable the swarm to achieve various collective behaviors including deployment, flocking and rendezvous.

Practical missions of robotic swarms require human interaction with the swarm at necessary times. Neglect Benevolence states that it may be more beneficial for the system if the human operator waits for some time before giving another subsequent command.

The performance measure that is used to demonstrate Neglect Benevolence, is the time taken by the robotic swarm to reach the human goal. By use of the consensus algorithm, the swarm agrees upon a final configuration. The time to that configuration is the natural time of the system. As the swarm moves towards its' goal, a human operator gives an input to send the swarm to a new final configuration.

## Problem

**Scenario:** During a mission, a human operator wants to give an input to change the direction of the swarm. The operator may want to explore another local area where the swarm's goal is currently not at.

When is the best time for a human operator to apply an input to a robotic swarm to optimize a performance criterion?

**Consider the following:**

Delaying the human input may be beneficial when the desired performance objective is:

- Minimize the time for the robotic swarm to reach a goal.
- Have the robotic swarm perform a task by a given deadline.

## Project Goal

The goal of this project is to demonstrate the principle of Neglect Benevolence using a system of turtlebots.

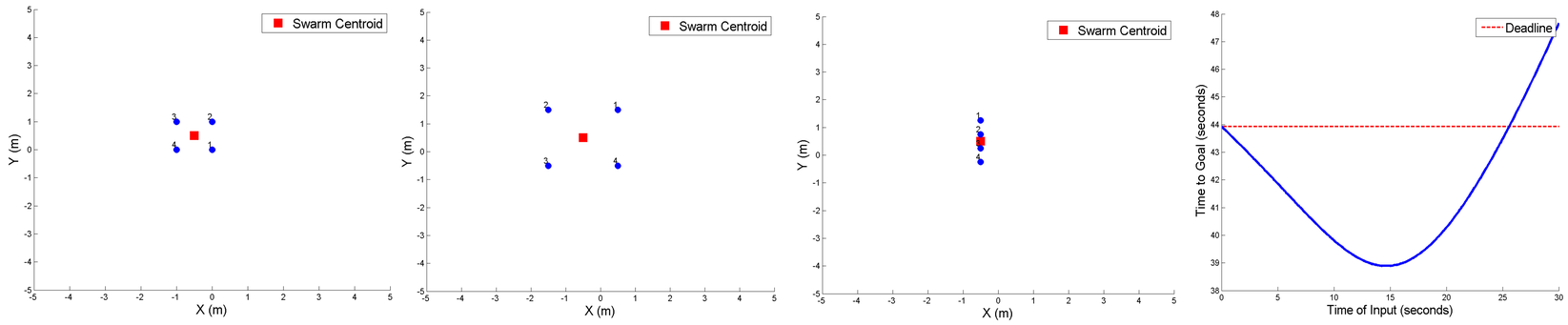
## Background

To demonstrate Neglect Benevolence, multiple turtlebots were used by use of ROS.

The Robot Operating System (ROS) is a set of software libraries and tools that help build robotic applications. Ranging from drivers to state-of-the-art algorithms, and with powerful developer tools.

## Simulation of Neglect Benevolence

In previous simulations, the timing of the human operator's input affected the system's performance.

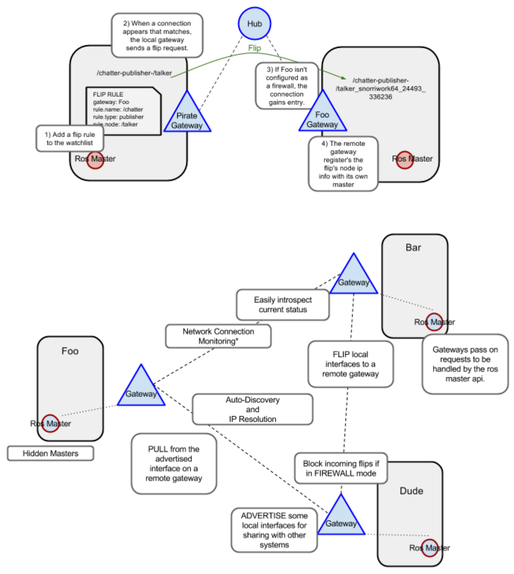



## Turtlebot Demonstration of Neglect Benevolence


Initial square position | Spatial square form | Line formation achieved

## Implementation

- A proportional controller is used for each turtlebot to go to a directed goal position.
- The gateway model provides a framework for multi-master communications in ROS. This allows each turtlebot to communicate its' current position to its' neighbor.
- The consensus algorithm is applied, so that the turtlebots can achieve rendezvous. The algorithm can be modified so that the turtlebots also achieve various spatial formations.
- Algorithms to calculate the time to the natural goal formation and secondary goal formation are applied. This allows the secondary input to be given at the optimal time.




## Conclusion

A successful demonstration of the principle, Neglect Benevolence, was shown using the turtlebots. A proportional controller is used to direct the turtlebots to a specific goal. The controller is more accurate by calculating the translational and angular goals separately rather than in parallel. The Rocon gateway system proves to be an appropriate solution for inter-master communication while running an interactive script to minimize configuration.

## Acknowledgement & Reference

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**Reference :**
S. Nagavalli, L. Luo, N. Chakraborty, & K. Sycara, "Neglect Benevolence in Human Control of Robotic Swarms," in 2014 IEEE International Conference on Robotics and Automation (ICRA 2014).